I claim:

1.   A vehicle control system, comprising: a force prediction unit for being placed in circuit communication with a tire deformation sensor and at least one other sensor, receiving a tire deformation input from the tire deformation sensor, and receiving at least one other tire sensor input from the at least one other sensor, said force prediction unit comprising a preprogrammed processor receiving the tire deformation input and the at least one other sensor input, said force prediction unit characterized by implementing preprogrammed equations having constants determined from previously collected data to determine from at least the tire deformation input and the at least one other sensor input an output corresponding to a predicted circumferential torque or longitudinal force acting on a tire.

2.   The vehicle control system of claim 1, wherein said preprogrammed processor of said force prediction unit executes code implementing a neural network trained with previously collected data to determine from at least the tire deformation input and the at least one other sensor input an output corresponding to a predicted circumferential torque or longitudinal force acting on the tire.

3.   The vehicle control system of claim 1, wherein said preprogrammed processor of said force prediction unit executes code implementing a multi-layer neural network trained with previously collected data to determine from at least the tire deformation input and the at least one other sensor input an output corresponding to a predicted circumferential torque or longitudinal force acting on the tire, said multi-layer neural network having an input layer, at least one hidden layer, and an output layer.

4.   The vehicle control system of claim 3, wherein said preprogrammed processor implements equations between said input layer and said at least one hidden layer in the form of a hyperbolic tangent sigmoidal transfer function, and wherein said preprogrammed processor implements equations between said hidden layer and said output layer in the form of a linear function.

5.   The vehicle control system of claim 1, wherein said preprogrammed processor of said force prediction unit executes code implementing an equation using constants determined using

multiple-linear-least squares regression analysis of previously collected data to determine from at least the tire deformation input and the at least one other sensor input an output corresponding to a predicted circumferential torque or longitudinal force acting on the tire.

6. The vehicle control system of claim 5, wherein the equation implemented by the preprogrammed processor of said force prediction unit is a bilinear equation.

7. The vehicle control system of claim 1, wherein said the tire deformation input and the at least one other sensor input comprise (a) a phase input related to a phase difference between the at least two sensors and indicative of torsional deformation of the tire and (b) an amplitude input related to a distance between the tire sidewall and the tire deformation sensor and indicative of a force acting on the tire, said preprogrammed processor accepting as inputs the phase input and the amplitude input and using at least the phase input and amplitude input to determine at least an output corresponding to a predicted circumferential torque or longitudinal force acting on the tire.

8. The vehicle control system of claim 2, wherein said the tire deformation input and the at least one other sensor input comprise (a) a phase input related to a phase difference between the at least two sensors and indicative of torsional deformation of the tire and (b) an amplitude input related to a distance between the tire sidewall and the tire deformation sensor and indicative of a force acting on the tire, said neural network accepting as inputs the phase input and the amplitude input and using at least the phase input and amplitude input to determine at least an output corresponding to a predicted circumferential torque or longitudinal force acting on the tire.

9. The vehicle control system of claim 6, wherein said the tire deformation input and the at least one other sensor input comprise (a) a phase input related to a phase difference between the at least two sensors and indicative of torsional deformation of the tire and (b) an amplitude input related to a distance between the tire sidewall and the tire deformation sensor and indicative of a force acting on the tire, said bilinear equation being a function of at least the phase input and the amplitude input to determine an output corresponding to a predicted circumferential torque or longitudinal force acting on the tire.

10. The vehicle control system of any of claims 1-9, wherein the tire deformation sensor comprises a magnetic tire sidewall torsion (SWT) sensor, said SWT sensor including a

magnetic sensor positioned proximate to a sidewall of the tire that has been magnetized with alternating magnetic poles.

11.   A vehicle control system, comprising: a force prediction unit for being placed in circuit communication with a tire deformation sensor and at least one other sensor, receiving a tire deformation input from the tire deformation sensor, and receiving at least one other tire sensor input from the at least one other sensor, said force prediction unit comprising a preprogrammed processor receiving the tire deformation input and the at least one other sensor input, said force prediction unit characterized by implementing preprogrammed equations having constants determined from previously collected data to determine from at least the tire deformation input and the at least one other sensor input an output corresponding to a predicted lateral force acting on a tire.

12.   The vehicle control system of claim 11, wherein said preprogrammed processor of said force prediction unit executes code implementing a neural network trained with previously collected data to determine from at least the tire deformation input and the at least one other sensor input an output corresponding to a predicted lateral force acting on the tire.

13.   The vehicle control system of claim 11, wherein said preprogrammed processor of said force prediction unit executes code implementing a multi-layer neural network trained with previously collected data to determine from at least the tire deformation input and the at least one other sensor input an output corresponding to a predicted lateral force acting on the tire, said multi-layer neural network having an input layer, at least one hidden layer, and an output layer.

14.   The vehicle control system of claim 13, wherein said preprogrammed processor implements equations between said input layer and said at least one hidden layer in the form of a hyperbolic tangent sigmoidal transfer function, and wherein said preprogrammed processor implements equations between said hidden layer and said output layer in the form of a linear function.

15.   The vehicle control system of claim 11, wherein said preprogrammed processor of said force prediction unit executes code implementing an equation using constants determined using multiple-linear-least squares regression analysis of previously collected data to determine from at

least the tire deformation input and the at least one other sensor input an output corresponding to a predicted lateral force acting on the tire.

16.   The vehicle control system of claim 15, wherein the equation implemented by the preprogrammed processor of said force prediction unit is a bilinear equation.

17.   The vehicle control system of claim 11, wherein said the tire deformation input and the at least one other sensor input comprise (a) a phase input related to a phase difference between the at least two sensors and indicative of torsional deformation of the tire and (b) an amplitude input related to a distance between the tire sidewall and the tire deformation sensor and indicative of a force acting on the tire, said preprogrammed processor accepting as inputs the phase input and the amplitude input and using at least the phase input and amplitude input to determine at least an output corresponding to a predicted lateral force acting on the tire.

18.   The vehicle control system of claim 12, wherein said the tire deformation input and the at least one other sensor input comprise (a) a phase input related to a phase difference between the at least two sensors and indicative of torsional deformation of the tire and (b) an amplitude input related to a distance between the tire sidewall and the tire deformation sensor and indicative of a force acting on the tire, said neural network accepting as inputs the phase input and the amplitude input and using at least the phase input and amplitude input to determine at least an output corresponding to a predicted lateral force acting on the tire.

19.   The vehicle control system of claim 16, wherein said the tire deformation input and the at least one other sensor input comprise (a) a phase input related to a phase difference between the at least two sensors and indicative of torsional deformation of the tire and (b) an amplitude input related to a distance between the tire sidewall and the tire deformation sensor and indicative of a force acting on the tire, said bilinear equation being a function of at least the phase input and the amplitude input to determine an output corresponding to a predicted lateral force acting on the tire.

20.   The vehicle control system of any of claims 11-19, wherein the tire deformation sensor comprises a magnetic tire sidewall torsion (SWT) sensor, said SWT sensor including a magnetic sensor positioned proximate to a sidewall of the tire that has been magnetized with alternating magnetic poles.

21.   A vehicle control system, comprising: a force prediction unit for being placed in circuit communication with a tire deformation sensor and at least one other sensor, receiving a tire deformation input from the tire deformation sensor, and receiving at least one other tire sensor input from the at least one other sensor, said force prediction unit comprising a preprogrammed processor receiving the tire deformation input and the at least one other sensor input, said force prediction unit characterized by implementing preprogrammed equations having constants determined from previously collected data to determine from at least the tire deformation input and the at least one other sensor input an output corresponding to a predicted vertical force acting on a tire.

22.   The vehicle control system of claim 21, wherein said preprogrammed processor of said force prediction unit executes code implementing a neural network trained with previously collected data to determine from at least the tire deformation input and the at least one other sensor input an output corresponding to a predicted vertical force acting on the tire.

23.   The vehicle control system of claim 21, wherein said preprogrammed processor of said force prediction unit executes code implementing a multi-layer neural network trained with previously collected data to determine from at least the tire deformation input and the at least one other sensor input an output corresponding to a predicted vertical force acting on the tire, said multi-layer neural network having an input layer, at least one hidden layer, and an output layer.

24.   The vehicle control system of claim 23, wherein said preprogrammed processor implements equations between said input layer and said at least one hidden layer in the form of a hyperbolic tangent sigmoidal transfer function, and wherein said preprogrammed processor implements equations between said hidden layer and said output layer in the form of a linear function.

25.   The vehicle control system of claim 21, wherein said preprogrammed processor of said force prediction unit executes code implementing an equation using constants determined using multiple-linear-least squares regression analysis of previously collected data to determine from at least the tire deformation input and the at least one other sensor input an output corresponding to a predicted vertical force acting on the tire.

26.   The vehicle control system of claim 25, wherein the equation implemented by the preprogrammed processor of said force prediction unit is a bilinear equation.

27.   The vehicle control system of claim 21, wherein said the tire deformation input and the at least one other sensor input comprise (a) a phase input related to a phase difference between the at least two sensors and indicative of torsional deformation of the tire and (b) an amplitude input related to a distance between the tire sidewall and the tire deformation sensor and indicative of a force acting on the tire, said preprogrammed processor accepting as inputs the phase input and the amplitude input and using at least the phase input and amplitude input to determine at least an output corresponding to a predicted vertical force acting on the tire.

28.   The vehicle control system of claim 22, wherein said the tire deformation input and the at least one other sensor input comprise (a) a phase input related to a phase difference between the at least two sensors and indicative of torsional deformation of the tire and (b) an amplitude input related to a distance between the tire sidewall and the tire deformation sensor and indicative of a force acting on the tire, said neural network accepting as inputs the phase input and the amplitude input and using at least the phase input and amplitude input to determine at least an output corresponding to a predicted vertical force acting on the tire.

29.   The vehicle control system of claim 26, wherein said the tire deformation input and the at least one other sensor input comprise (a) a phase input related to a phase difference between the at least two sensors and indicative of torsional deformation of the tire and (b) an amplitude input related to a distance between the tire sidewall and the tire deformation sensor and indicative of a force acting on the tire, said bilinear equation being a function of at least the phase input and the amplitude input to determine an output corresponding to a predicted vertical force acting on the tire.

30.   The vehicle control system of any of claims 21-29, wherein the tire deformation sensor comprises a magnetic tire sidewall torsion (SWT) sensor, said SWT sensor including a magnetic sensor positioned proximate to a sidewall of the tire that has been magnetized with alternating magnetic poles.

31.   The vehicle control system of claim 1, wherein said force prediction unit is further characterized by implementing preprogrammed equations having constants determined from

37

previously collected data to determine from at least the tire deformation input and the at least one other sensor input (a) an output corresponding to a predicted circumferential torque or longitudinal force acting on the tire and (b) an output corresponding to a predicted force acting on the tire that is skewed with respect to the longitudinal force acting on the tire.

32.   The vehicle control system of claim 31, wherein said force prediction unit is further characterized by implementing preprogrammed equations having constants determined from previously collected data to determine from at least the tire deformation input and the at least one other sensor input (a) an output corresponding to a predicted circumferential torque or longitudinal force acting on the tire and (b) an output corresponding to a predicted lateral force acting on the tire.

33.   The vehicle control system of claim 31, wherein said force prediction unit is further characterized by implementing preprogrammed equations having constants determined from previously collected data to determine from at least the tire deformation input and the at least one other sensor input (a) an output corresponding to a predicted circumferential torque or longitudinal force acting on the tire and (b) an output corresponding to a predicted vertical force acting on the tire.

34.   The vehicle control system of claim 10, wherein said force prediction unit is further characterized by implementing preprogrammed equations having constants determined from previously collected data to determine from at least the tire deformation input and the at least one other sensor input (a) an output corresponding to a predicted lateral force acting on the tire and (b) an output corresponding to a predicted force acting on the tire that is skewed with respect to the lateral force acting on the tire.

35.   The vehicle control system of claim 34, wherein said force prediction unit is further characterized by implementing preprogrammed equations having constants determined from previously collected data to determine from at least the tire deformation input and the at least one other sensor input (a) an output corresponding to a predicted lateral force acting on the tire and (b) an output corresponding to a predicted vertical force acting on the tire.

36.   The vehicle control system of claim 20, wherein said force prediction unit is further characterized by implementing preprogrammed equations having constants determined from

38

previously collected data to determine from at least the tire deformation input and the at least one other sensor input (a) an output corresponding to a predicted vertical force acting on the tire and (b) an output corresponding to a predicted force acting on the tire that is skewed with respect to the vertical force acting on the tire.

37.   A vehicle control system comprising:

(a)   a force prediction unit for being placed in circuit communication with a tire deformation sensor and at least one other sensor, receiving a tire deformation input from the tire deformation sensor, and receiving at least one other tire sensor input from the at least one other sensor, said force prediction unit comprising a preprogrammed processor receiving the tire deformation input and the at least one other sensor input, said force prediction unit characterized by implementing preprogrammed equations having constants determined from previously collected data to determine from at least the tire deformation input and the at least one other sensor input an output corresponding to a predicted circumferential torque or longitudinal force acting on a tire and outputting a predicted circumferential torque or longitudinal force output corresponding to the predicted circumferential torque or longitudinal force acting on the tire; and

(b)   a control unit in circuit communication with said force prediction unit for receiving the predicted circumferential torque or longitudinal force output and for being placed in circuit communication with vehicle actuators, said control unit characterized by altering the dynamic state of the vehicle via the actuators responsive at least in part to the predicted circumferential torque or longitudinal force output from the force prediction unit.

38.   A vehicle control system comprising:

(a)   a force prediction unit for being placed in circuit communication with a tire deformation sensor and at least one other sensor, receiving a tire deformation input from the tire deformation sensor, and receiving at least one other tire sensor input from the at least one other sensor, said force prediction unit comprising a preprogrammed processor receiving the tire deformation input and the at least one other sensor input, said force prediction unit characterized by implementing

preprogrammed equations having constants determined from previously collected data to determine from at least the tire deformation input and the at least one other sensor input an output corresponding to a predicted lateral force acting on a tire and outputting a predicted lateral force output corresponding to the predicted lateral force acting on the tire; and

(b)   a control unit in circuit communication with said force prediction unit for receiving the predicted lateral force output and for being placed in circuit communication with vehicle actuators, said control unit characterized by altering the dynamic state of the vehicle via the actuators responsive at least in part to the predicted lateral force output from the force prediction unit.

39.   The vehicle control system of claim 38, wherein said control unit has associated therewith a plurality of μ-slip curves, each of said μ-slip curves being associated with a different lateral force, said control unit implementing an anti-lock braking system based on a selected one of said μ-slip curves, and further wherein said control unit is characterized by selecting the of said plurality of μ-slip curves responsive at least in part to the predicted lateral force output from the force prediction unit and using the selected one of said plurality of μ-slip curves to implement anti-lock braking.

40.   A vehicle control system comprising:

(a)   a force prediction unit for being placed in circuit communication with a tire deformation sensor and at least one other sensor, receiving a tire deformation input from the tire deformation sensor, and receiving at least one other tire sensor input from the at least one other sensor, said force prediction unit comprising a preprogrammed processor receiving the tire deformation input and the at least one other sensor input, said force prediction unit characterized by implementing preprogrammed equations having constants determined from previously collected data to determine from at least the tire deformation input and the at least one other sensor input an output corresponding to a predicted vertical force acting on a tire and outputting a predicted vertical force output corresponding to the predicted vertical force acting on the tire; and

(b)   a control unit in circuit communication with said force prediction unit for receiving the predicted vertical force output and for being placed in circuit communication with vehicle actuators, said control unit characterized by altering the dynamic state of the vehicle via the actuators responsive at least in part to the predicted vertical force output from the force prediction unit.

41.   A method of predicting the circumferential torque or longitudinal force acting on a tire, comprising the steps of:

(a)   providing a force prediction unit for being placed in circuit communication with a tire deformation sensor and at least one other sensor, receiving a tire deformation input from the tire deformation sensor, and receiving at least one other tire sensor input from the at least one other sensor, said force prediction unit comprising a preprogrammed processor receiving the tire deformation input and the at least one other sensor input, said force prediction unit characterized by implementing preprogrammed equations having constants determined from previously collected data to determine from at least the tire deformation input and the at least one other sensor input an output corresponding to a predicted vertical force acting on a tire;

(b)   collecting tire deformation input from the tire deformation sensor and the at least one other tire sensor input from the at least one other sensor; and

(c)   determining with the force prediction unit the circumferential torque or longitudinal force acting on a tire from the collected tire deformation input and the collected at least one other tire sensor input.

42.   A method of training a neural network to determine the circumferential torque or longitudinal force acting on a tire from a tire deformation sensor and at least one other sensor, comprising the steps of:

(a)   collecting tire deformation input from a tire deformation sensor and at least one other tire sensor input from at least one other sensor;

(b)   collecting an input corresponding to the circumferential torque or longitudinal force acting on the tire;

(c)   training the neural network to predict the circumferential torque or longitudinal force acting on a tire using as training data at least the collected tire deformation input, the collected at least one other tire sensor input, and the collected input corresponding to the circumferential torque or longitudinal force acting on the tire.